

MODIS Semi-annual Report (July 1999 - December 1999)

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(This reports covers the MODIS **cirrus characterization and correction** algorithm and part of the MODIS **near-IR water vapor algorithm**)

Main topics addressed in this time period:

1. MODIS near-IR water vapor algorithm:

Science algorithm: The new MODIS PGE04 algorithms including aerosol, near-IR water vapor, and water vapor correction modules were delivered in September for the integration into MODIS data production systems. Parts of the near-IR water vapor algorithm and the water vapor correction module for aerosol effects were re-written in F90. Minor bugs in earlier versions of the codes were fixed. The new codes avoided quite a few nested DO and IF loops. The routines re-written in F90 for multi-dimensional table-searching and interpolation greatly speeded up the retrieval processes.

Validation: MAS data collected during different field experiments were used to validate and to check the performance of near-IR water vapor algorithm. Specifically, water vapor images were derived from large volumes of MAS data collected during SCAR-B field experiment. It was found that smokes had little effects on water vapor retrievals. The derived water vapor values for different viewing angles had no systematic bias. The MAS and LASE data collected during TARFOX experiment were also analyzed. It was concluded that total precipitable water could be derived over ocean glint regions using a 2-channel ratio technique (0.94 micron / 0.86 micron).

2. MODIS thin cirrus and contrail algorithm:

The science algorithm includes two parts: thin cirrus reflectance and contrail detection. The revised and re-packaged algorithms were delivered to MODIS Project in early October. P. Yang continued his work on improving the accuracy of MODIS thin cirrus algorithm. He developed a better algorithm to obtain the "slope" factor from scatter plots of 0.66 micron image versus 1.375 micron image. He validated this algorithm using AVIRIS data. Minor progress was made in the further development of the contrail detecting algorithm.

3. MODAPS PI Processing, Visualization

As the Atmosphere Group's PI Processing representative, Ridgway played significant roles in supporting the MODAPS (L2 and L3) processing and MODIS L1 integration (in the GDAAC). He represented Atmosphere's Science Team Members in monthly PI Processing meetings that included planning and debriefing for MODAPS operational readiness, oversight of MODIS Atmosphere's PGE development and testing, assessments of MODAPS-to-DAAC L2/L3 product insertions, and analysis of processed products based on L1B synthetic data. Notable achievements by the Atmosphere Team included PGE06 optimization that significantly reduced Atmosphere's total processing requirements and development of visualization and sub-setting tools to support offsite data analysis and validation studies.

The visualization tools for viewing MODIS L1B and L2 images at full spatial resolution and with corrections to instrument effects (e.g., the "bow-tie" effect) are still lacking. We ported over a software package called HDFLOOK from the MODIS Land Group. This package allows the viewing and dumping of images from huge HDF files. It does not correct for the "bow-tie" effects, which are present in the L1B and L2 data products. The bow-tie effects distort images at large looking angles. Coastal lines may appear zigzagged. An isolated cumulus cloud may appear at several pixels. The bow-tie effects need to be removed in order to obtain nice-looking level-2 images. We also copied over another set of software developed by the MODIS Land Group for producing the L2G data products. We tested this package. The package with numerous links seemed to be difficult to use. We recently copied another set of software from TRMM group. We were able to display synthetic MODIS L1B images at regular latitude and longitude grids (without distortion).

4. Radiative Transfer Modeling:

Cirrus clouds, primarily in the upper troposphere and lower stratosphere, have a profound impact on the terrestrial climate system through their radiative effect. The detection of cirrus clouds and retrieval of their optical and microphysical properties are among the key objectives of MODIS project. These clouds are composed of exclusively of nonspherical ice crystals. The absorption and scattering properties of nonspherical ice crystals are fundamental to radiative transfer calculations and remote sensing applications involving cirrus clouds. In the past six months, P. Yang developed an efficient radiative transfer code that is especially suitable to the phase function with large asymmetry such as those for cirrus clouds. This code has been validated against the results

computed by various other methods. This code will be useful in investigating the radiative properties of clouds at MODIS channels.

P. Yang also studied the effect of vertically inhomogeneity of cirrus structure on the bi-directional reflectance of these clouds at MODIS visible and near-infrared bands. He constructed a three-layer cirrus model regarding ice crystal habits and size distributions based on in situ observed data acquired during NASA FIRE-II field experimental program. He has found that at $0.65\ \mu\text{m}$, where absorption by ice is negligible, there is little difference between the bidirectional reflectances calculated between the one-layer and three-layer models, suggesting that vertical inhomogeneity is relatively unimportant. At $2.11\ \mu\text{m}$, the bidirectional reflectances computed for both optically thin ($\tau = 1$) and thick ($\tau = 10$) cirrus clouds show significant differences between the one-layer and three-layer models. The reflectances computed for the three-layer cirrus model are substantially larger than those computed for the single-layer cirrus. He also found that the reflectance of cirrus is very sensitive to the optical properties of small particles that predominate in the top layer of the three-layer cirrus model, and it is critical to define the most realistic geometric shape for the small “quasi-spherical” ice crystals in the top layer for obtaining reliable bulk radiative properties of cirrus.

In collaborating with Drs. Bryan Baum, Peter Soulen, and Y. X. Hu, P. Yang studied the effect of ice crystal shapes on the retrieval of mean effective size and optical thickness of cirrus. P. Yang did some studies on the nonsphericity of aerosols on aerosols radiative properties at MODIS channels. Preliminary results show that aerosol nonsphericity has a substantial effect on single-scattering properties. P. Yang is studying this effect on multiple scattering involved in radiative transfer within aerosol layers.

5. Meeting

Ridgway, Yang, and Gao participated the 10th conference on atmospheric radiation organized by American Meteorological Society in Madison, Wisconsin from 28 June to 2 July. Gao had a poster on cirrus detection. Yang had a presentation on the parameterization of scattering and absorption properties for individual ice crystals. Yang attended a workshop on Ice Clouds: Oct. 28-29, 1999. Madison, WI.

Yang gave two invited talks – (a): “Radiative Properties of Cirrus clouds” presented at The Cooperative Institute of Meteorology Satellite Studies (CIMMS)/University of Wisconsin, Madison. Oct. 27, 1999, Madison, WI; and (b): “Modeling Light Scattering by Ice Crystals in Cirrus Clouds” presented at The Department of Physics and Astronomy, Howard University, Nov. 17, 1999, DC.

6. Publications

- Gao, B.-C., A practical method for simulating AVHRR-consistent NDVI data series using narrow MODIS channels in the 0.5 - 1.0 μm spectral range, accepted for publication by IEEE Transa. Geosci. Remote Sens. in December, 1999.
- Gao, B.-C., and R.-R. Li, Quantitative improvement in the estimates of NDVI values from remotely sensed data by correcting thin cirrus scattering effects, Remote Sens. Env. (*in press*).
- Gao, B.-C., Y. J. Kaufman, R. R. Li, and W. J. Wiscombe, Correction of thin cirrus scattering effects in the 0.4 - 1.0 μm spectral region using the 1.375- μm channel for improved remote sensing of tropospheric aerosols, land surface, and ocean color, in the *Proceedings of the 10th Conference on Atmospheric Radiation*, Madison, Wisconsin, Vol. 1, pp 413-415, June 28 - July 2, 1999.
- Yang, P., and K. N. Liou, Finite difference time domain method for light scattering by nonspherical particles. Chapter 7 in Light scattering by nonspherical particles: theory, measurements, and geophysical applications, Eds. M. I. Mishchenko, J. W. Hovenier, and L. D. Travis (accepted and in press), 1999.
- Yang, P., K. N. Liou, K. Wyser, and D. Mitchell, Parameterization of the scattering and absorption properties of individual ice crystals, J. Geophys. Res. (accepted and in press), 1999.
- Wyser, K. and P. Yang, On the uncertainties of the refractive index of ice, Contr. Atmos. Phys./Beitr. Phys. Atmos. (accepted and in press), 1999.
- Soulen, P. F., P. Yang, Y. X. Hu, S. Nasiri, and B. Baum, Effect of crystal habits on retrieving optical thickness and effective radius of ice clouds using MODIS: a sensitivity study (submitted to Geophys. Res. Lett.).
- Yang, P., B.-C. Gao, B. A. Baum, and co-authors, Sensitivity of cirrus bidirectional reflectance at MODIS bands to vertical inhomogeneous of ice crystal habits and size distributions (to be submitted to J. Geophys. Res.)